The Hybrid Optimization Model for Electric Renewables (HOMER)

by Peter Lilienthal 12/99

Background

Hybrid power systems can consist of any combination of wind, photovoltaics, diesel, and batteries. Such flexibility has obvious advantages for customizing a system to a particular site's energy resources, costs, and load requirements. Flexibility also makes the design process more difficult.

Scope

The National Renewable Energy Laboratory (NREL) has developed *HOMER*, an optimization model that considers hourly and seasonal variations in loads and resources, simple performance characterizations for each component, equipment costs, reliability requirements, and other site-specific information. *HOMER* ranks the configurations by life-cycle cost and can automatically perform sensitivity analyses on any subset of its inputs. It is intended for prefeasibility analysis when the interest spans a broad range of inputs, either because the input data is uncertain or because the analysis covers a large area with differing conditions. In addition to performing optimized configurations, *HOMER* provides hourly energy flows through each component, the impact of several simple load management strategies, and economic information such as the cost of energy and net cost of the system.

Results

NREL researchers have used *HOMER* in several analyses for the Philippines, Indonesia, China, Russia, Argentina, Chile, Brazil, Mexico, South Africa, and for market analyses for domestic renewable energy suppliers and technology developers. It also has been used for market assessment and screening to initialize detailed site-specific *Hybrid2* analyses.

There are now two versions of *HOMER*. *HOMER Express* is a simple version intended for planners unfamiliar with hybrid renewables. *HOMER Pro* is an advanced version intended for use by renewable energy or rural electrification professionals. If hourly load data is not available, it can be synthesized using typical days for each month, with a user-specified level of additional variability. Hourly solar and wind resource data can also be synthesized from monthly averages if measured hourly data is not available. A grid extension module has been added, allowing a cost comparison between stand-alone hybrid power systems and the traditional extension of the electrical grid. The output capabilities of *HOMER* have been dramatically improved. Any of the annual outputs (including the optimal system type) can now be plotted versus one or two sensitivity variables.

HOMER reports both optimal and near-optimal solutions. It has been integrated with a grid optimization model, *ViPOR*, to help planners compare grid extension, minigrids, and individual systems for a particular village.

Sample files have been created that compile the results of more than a million annual simulations into a sensitivity analysis that shows the optimal design over a wide range of load, resource, and economic parameters.

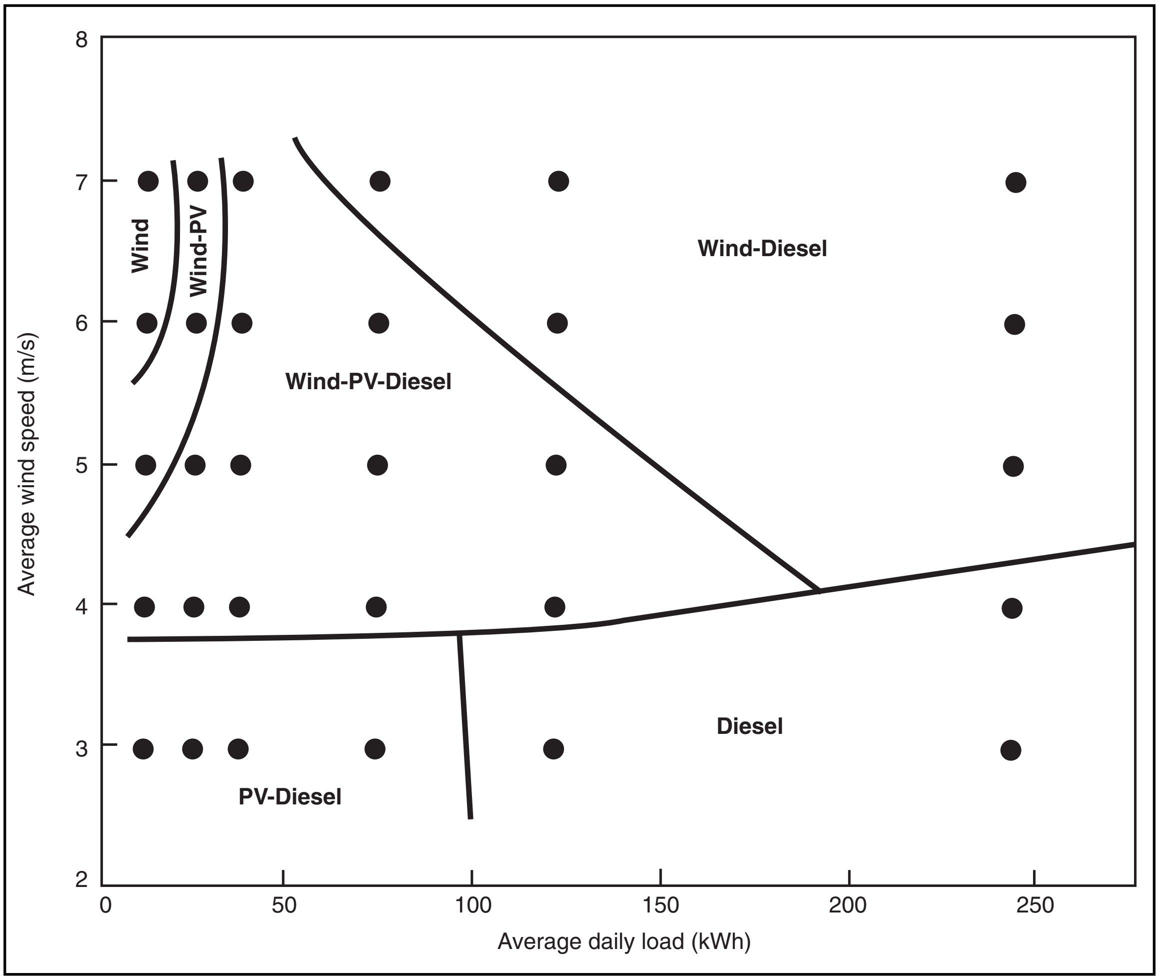
Planned Activities

HOMER will continue to be used for system screening and market assessment. A large number of enhancements are planned for the near future, including the addition of micro-hydro and biomass power technologies and integration with a Geographic Information System. The grid extension module will be enhanced to allow *HOMER's* use for grid-connected distributed generation. A complete package of documentation is also being produced.

NREL Contact

Web site: *http://www.rsvp.nrel.gov*
or
http://www.nrel.gov/international/homer

Peter Lilienthal
phone: 303-384-7444
fax: 303-384-7411
e-mail: peter_lilienthal@nrel.gov



HOMER. *Assessing the "least" cost mix of supply technologies is a difficult analytical problem that depends on the quality of the various resources, the local costs of equipment, labor and fuel, and the site-specific descriptions of the daily and seasonal variations in the loads, as well as the options for simple load management. The Hybrid Optimization Model for Electric Renewables (HOMER) is a screening model that is useful for prefeasibility and sensitivity analysis. This graph is an example of a set of HOMER outputs for specific sets of assumptions. The results can change dramatically with different assumptions.*

Sensitivity analyses were performed on the size of the load and the average annual windspeed. For very low loads in a good wind resource, one small wind turbine will produce more energy than required. In lesser wind resources or as the load increases, a combination of wind and PV is preferred. Although in this example PV-diesel is the optimal choice in poor wind resources for the smallest loads that were modeled (12 kWh/day), a pure PV system would be preferred for smaller loads or higher fuel prices or if more than 5% unserved energy would be acceptable. In the larger sizes, both wind turbines and diesel gen-sets have economies of scale that make PV less competitive. The vertical line representing 125 kWh/day demonstrates a seemingly counter-intuitive insight from the model. At moderate windspeeds PV is cost-effective, even though it was not cost-effective at low windspeeds. This is because the cost of the balance of systems required to utilize PV (batteries and inverter) is being shared by the wind turbines.

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